Paul Scherrer Institut

LABOR FÜR ATMOSPHÄREN-CHEMIE

Sensitivity of Ozone and Secondary Aerosol Formation to Emissions in Switzerland

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Goal

Ozone (June 2006):

- sensitivity to anthropogenic precursor (NO_x and VOC) emissions and comparison with 1993

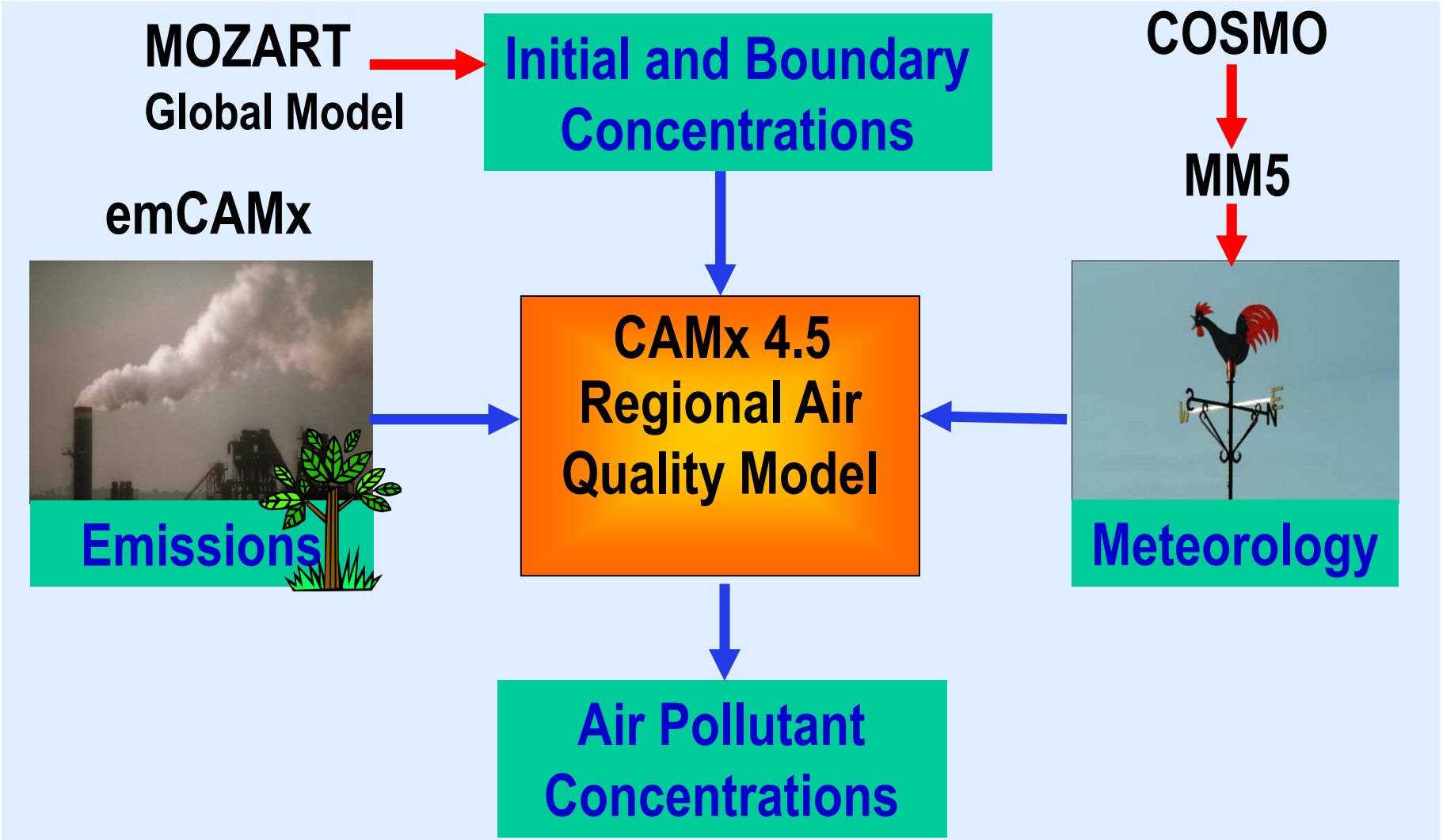
- sensitivity to isoprene emissions

Aerosols (January, June 2006):

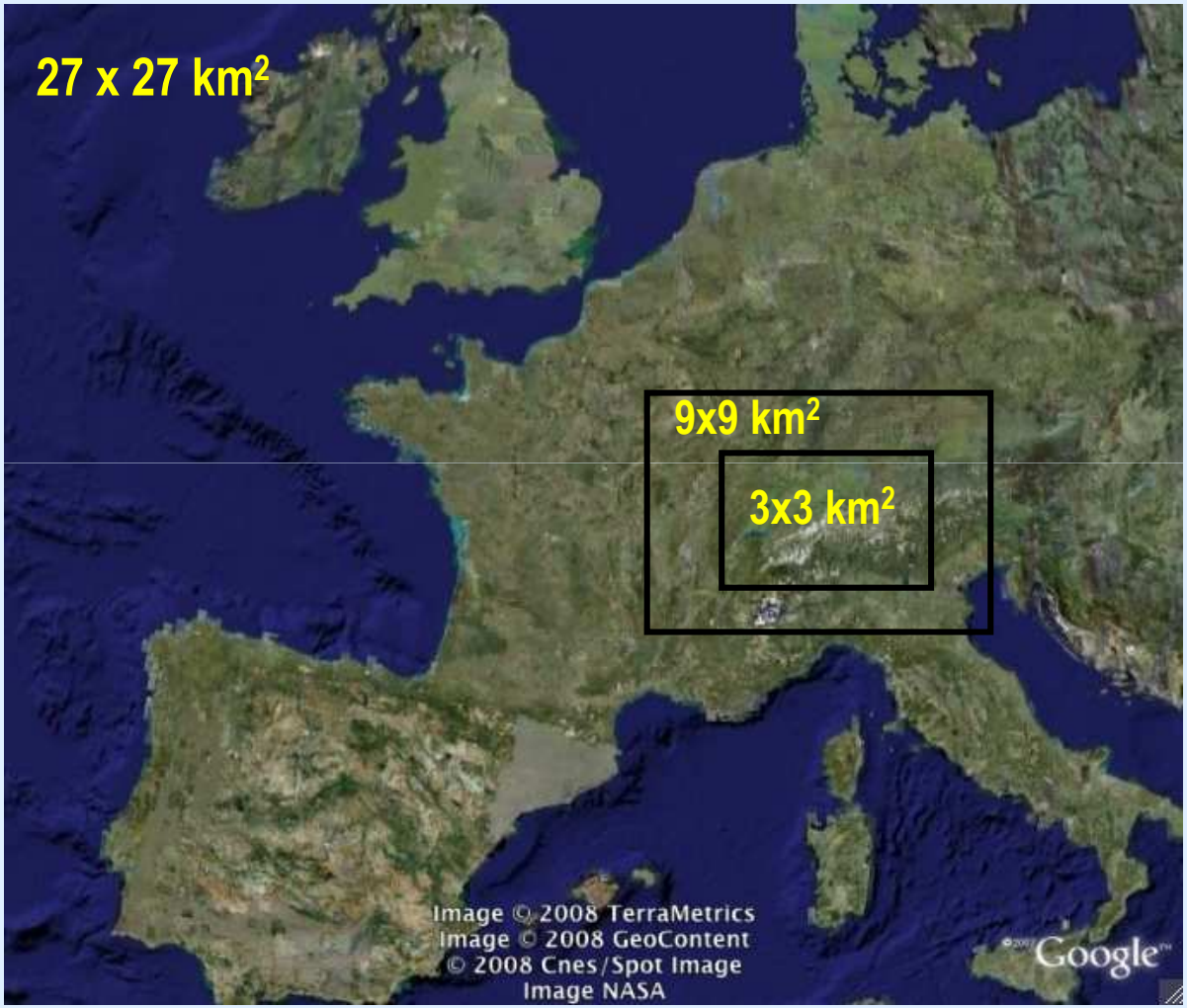
- Inorganic Aerosols: sensitivity to NO_x and NH_3 emissions

- Organic Aerosols: contribution of primary organic aerosol (POA) emissions
  contribution of biogenic VOC (BVOC) emissions to secondary organic aerosol (SOA)

Components of the Air Quality Model



Modelling Method



- 31 layers in MM5
- 14 layers in CAMx

- 1-31 January 2006
- 1-30 June 2006

- CB05 gas -phase mechanism

- PM2.5

- 7 SOA classes

- oligomerization

Sensitivity tests

Ozone

NO_x emissions (%)	*100, 90, 70, 50*
VOC emissions (%)	*100, 90, 70, 50*
Isoprene emissions (factor)	*1, 20*

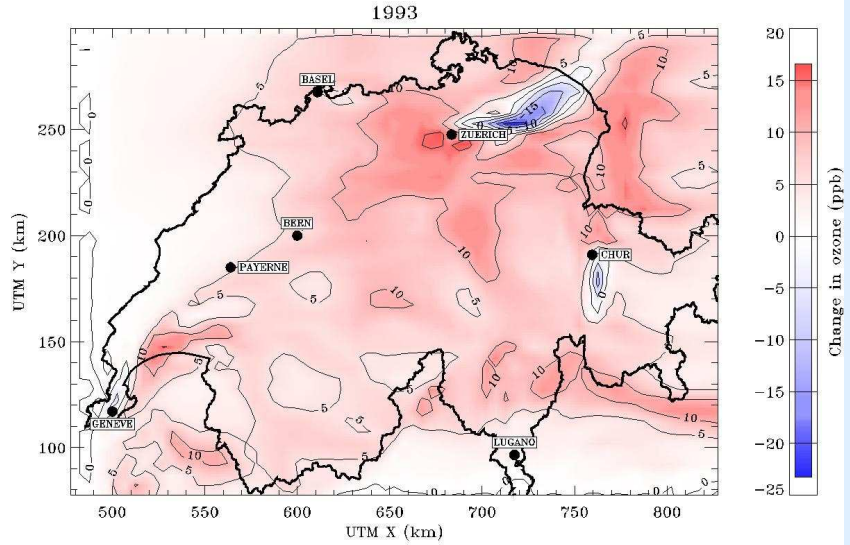
Aerosols

NO_x emissions (%)	*100, 50*
NH_3 emissions (%)	*100, 50*

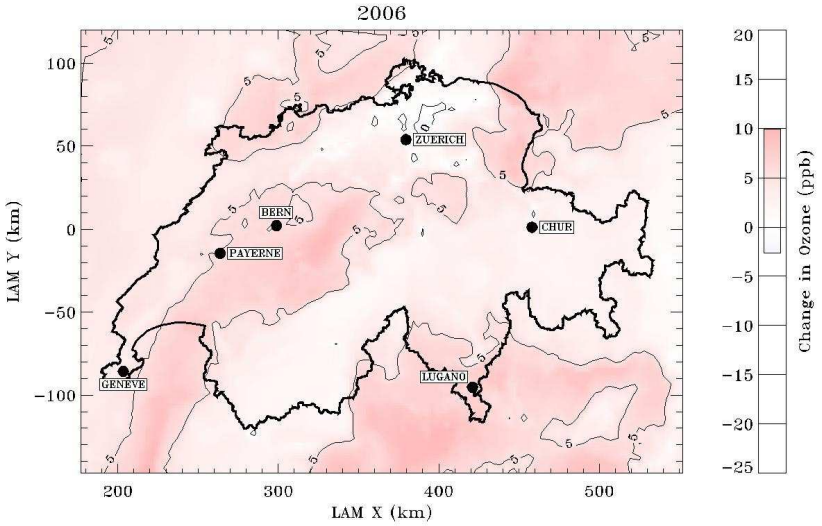
Ozone : Sensitivity to Precursor Emissions

Base Case - 50% NO_x

1993



2006



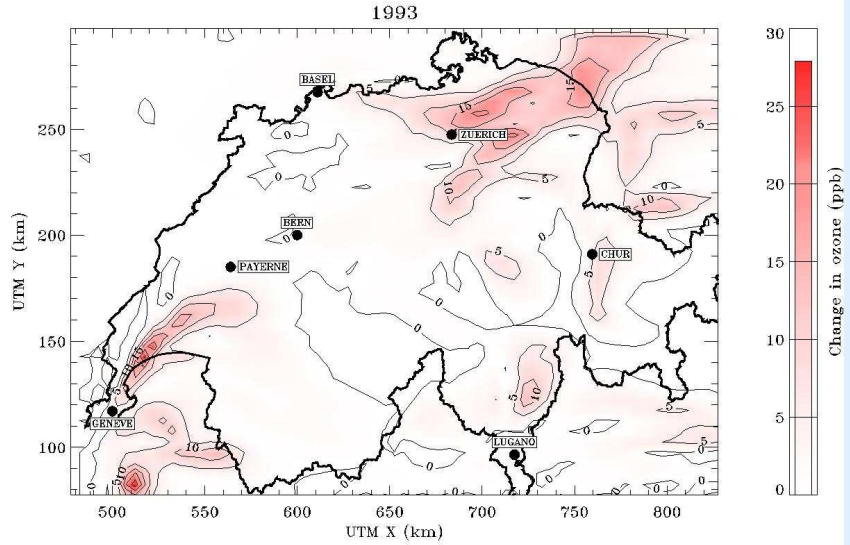
blue : increase in peak ozone

red : decrease in peak ozone

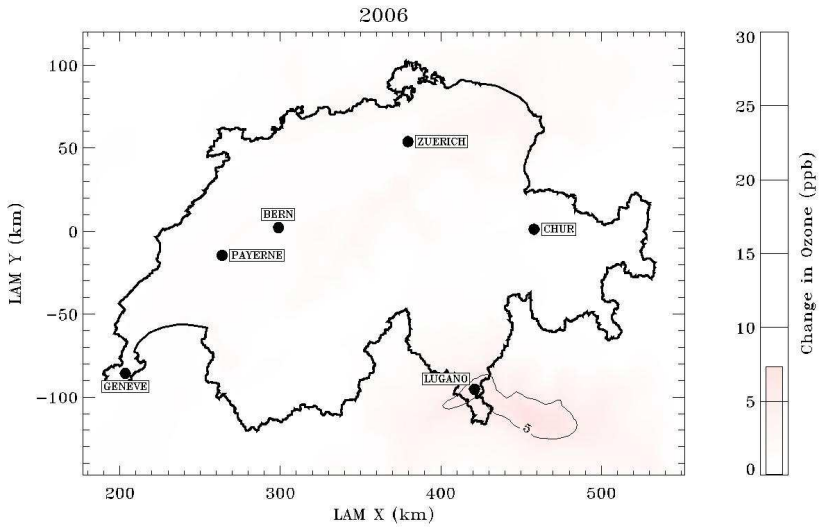
Ozone : Sensitivity to Precursor Emissions

Base Case - 50% VOC

1993



2006



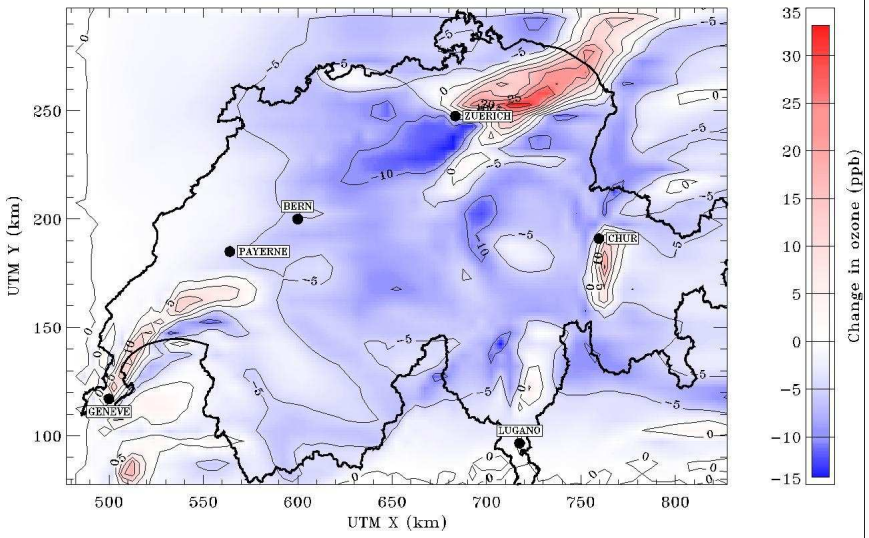
blue : increase in peak ozone

red : decrease in peak ozone

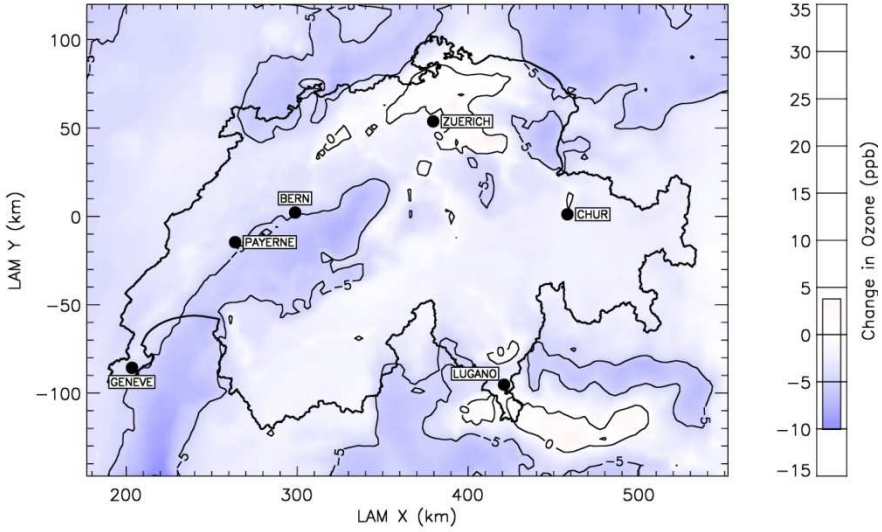
Ozone : Sensitivity to Precursor Emissions

O_3 (50% NO_x) - O_3 (50% VOC)

1993



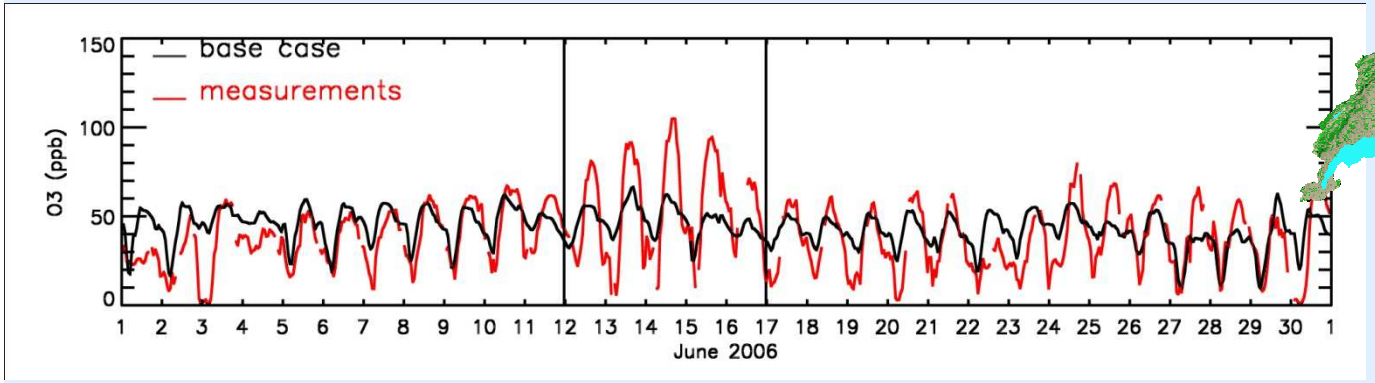
2006

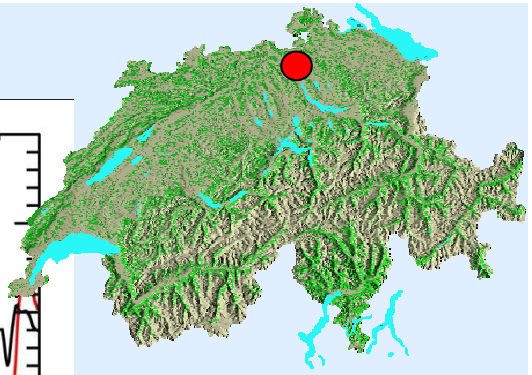


blue : NO_x-sensitive red : VOC-sensitive

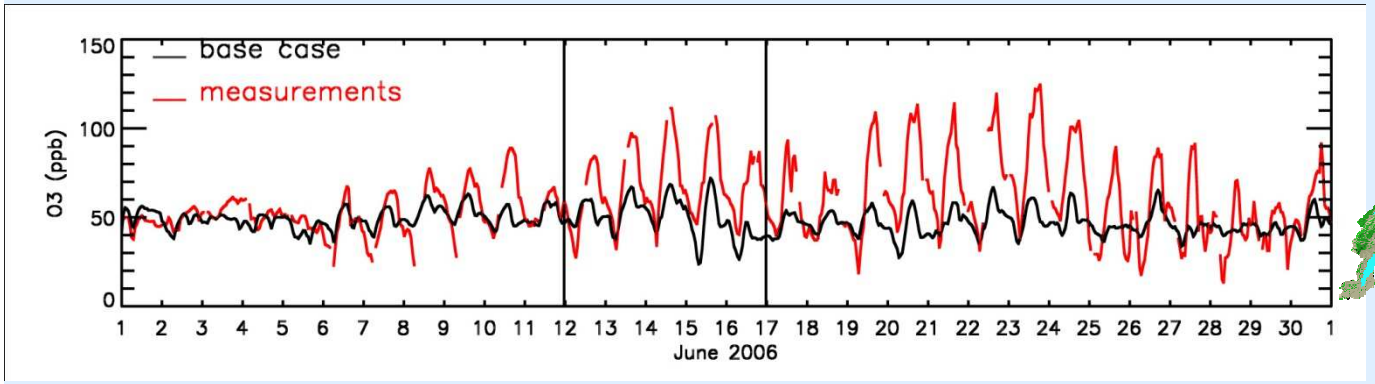
Ozone : Sensitivity to Isoprene Emissions

Zurich, north



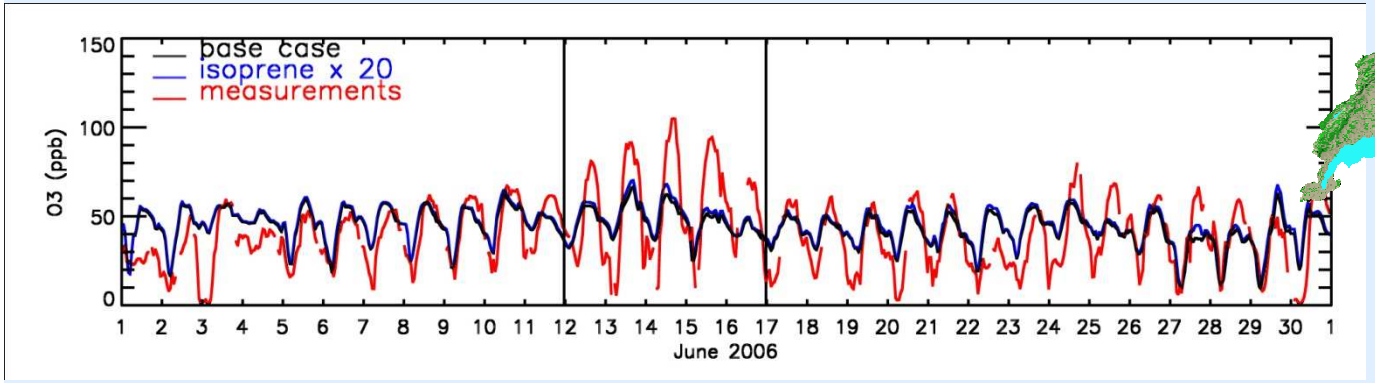


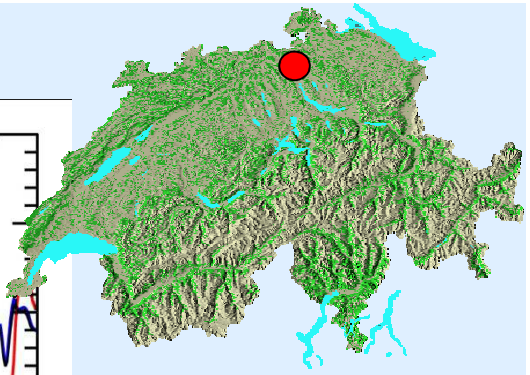
Lugano, south



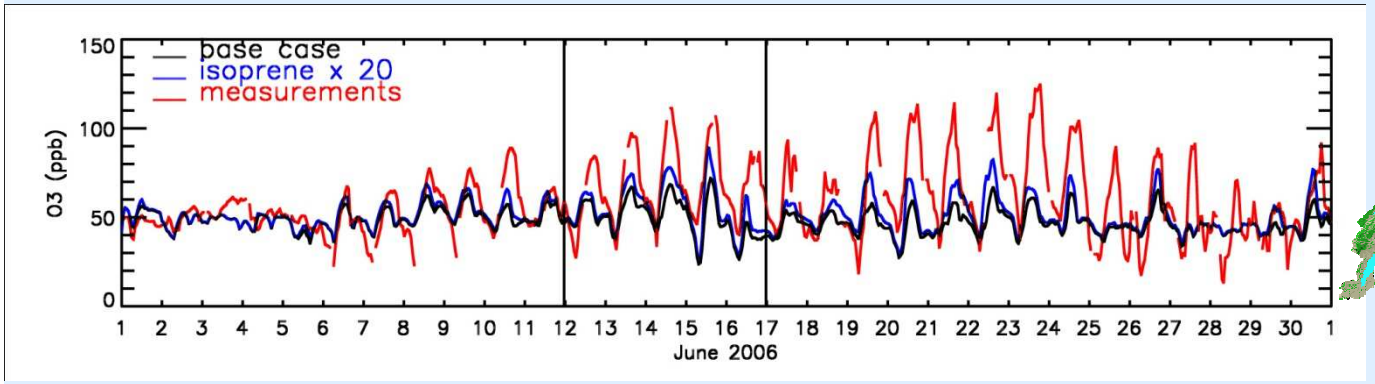
Ozone : Sensitivity to Isoprene Emissions

Zurich, north

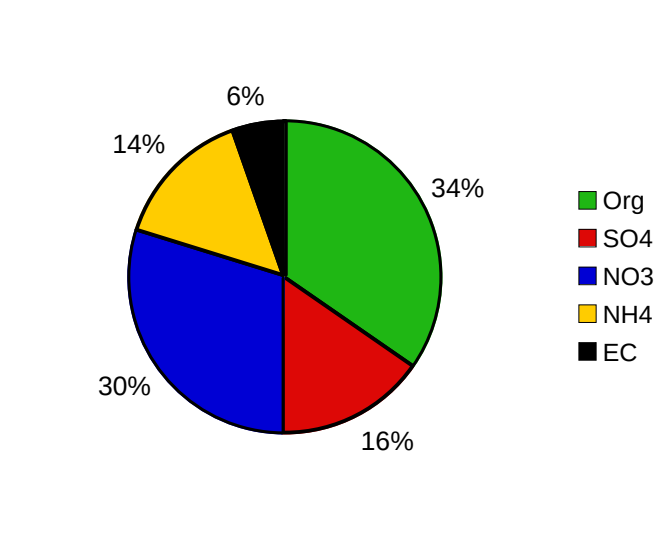




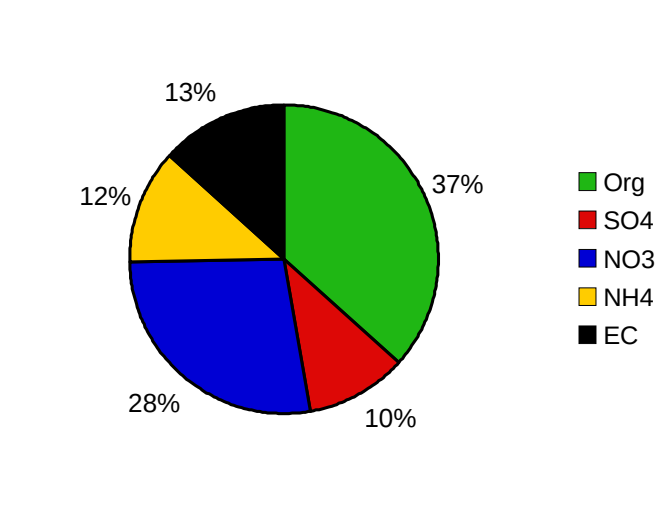
Lugano, south



Aerosols: Relative contributions (winter 2006, Zurich)



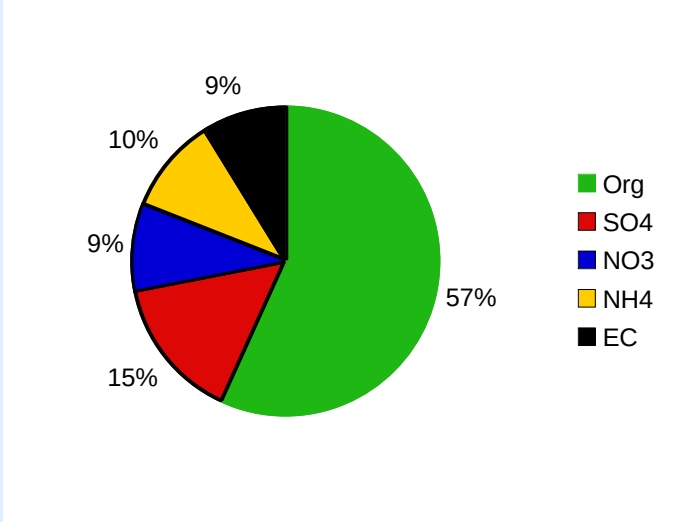
Measurements



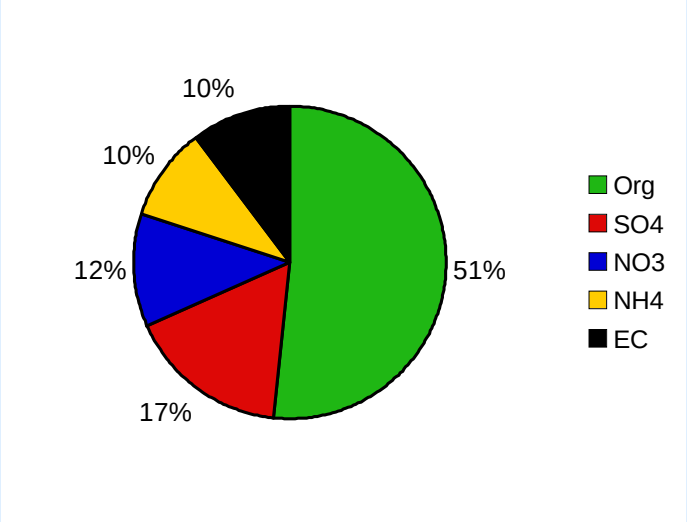
Model predictions

Organic aerosols and particulate nitrate are the main components

Aerosols: Relative contributions (summer 2006, Payerne)



Measurements

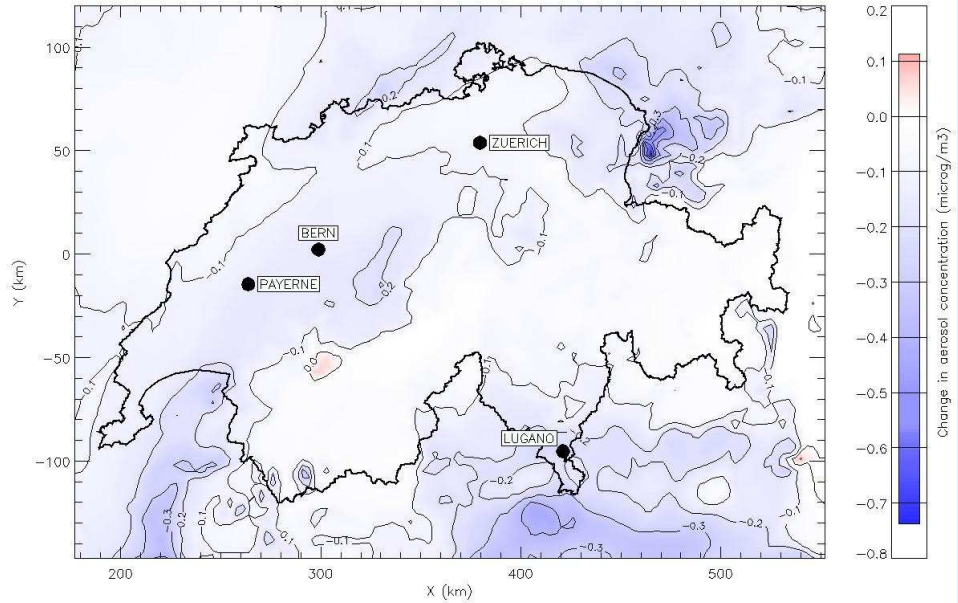


Model predictions

Organic aerosols are the main components

Inorganic Aerosols : Sensitivity to NO_x, NH_3 emissions

aerosol mass (50% NO_x) - aerosol mass (50% NH_3)



15 June 2006, afternoon

Blue : NO_x-sensitive
Red : NH_3-sensitive

enough ammonia is available,
formation of inorganic aerosols is limited by NO_x emissions

Organic Aerosols : Mechanism in CAMx 4.5

Primary Organic Aerosol (POA) *emitted*

Secondary Organic Aerosol (SOA) *formed from precursors:*

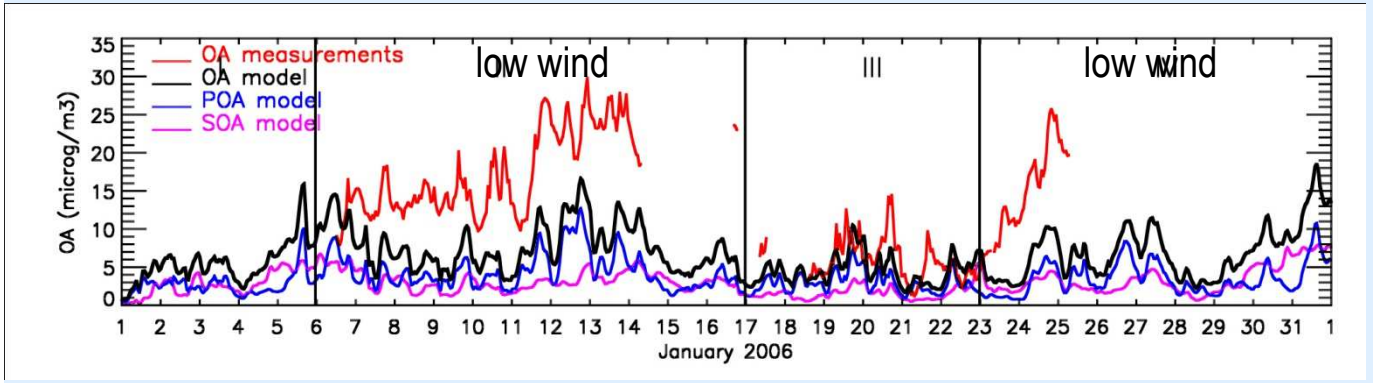
anthropogenic : toluene, xylene (AROM)
biogenic : isoprene (ISP)
biogenic : monoterpenes (TRP)
biogenic : sesquiterpenes (SQT)

formed from oligomerization of:

anthropogenic SOA : AROM (SOPA)
biogenic SOA : ISP, TRP (SOPB)

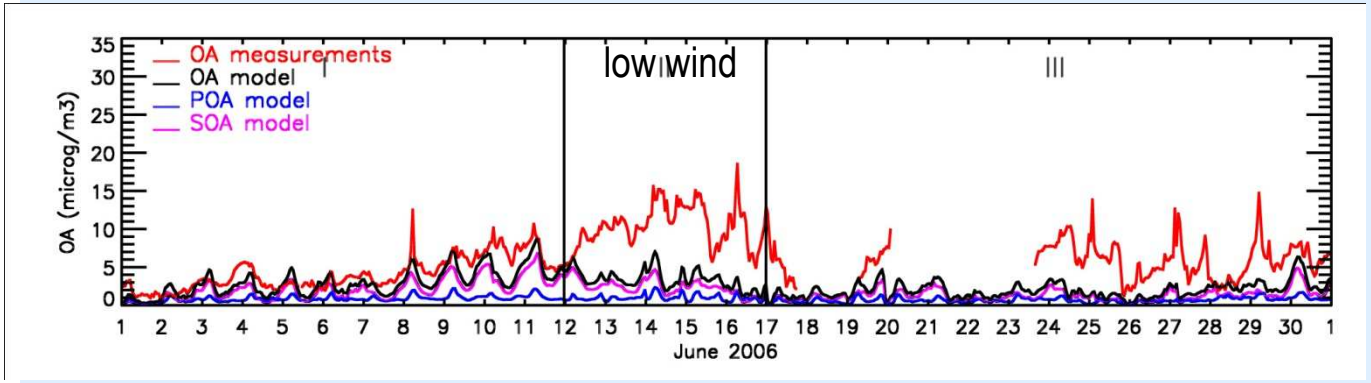
Organic Aerosols : Contribution of POA emissions

January 2006, Zurich



	Model (%)	Obs. (%)
POA	56	45
SOA	44	55

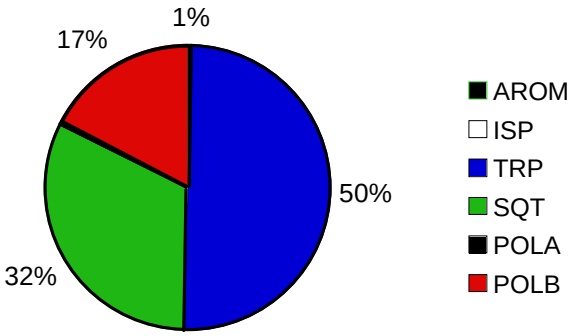
June 2006, Payerne



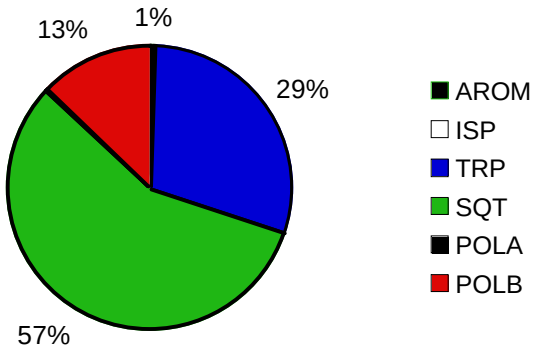
POA	31	6
SOA	69	94

Organic Aerosols : Contribution of BVOC emissions to SOA

winter 2006 (Zurich)



summer 2006 (Payerne)



AROM : SOA from toluene and xylene
ISP : SOA from isoprene
TRP : SOA from monoterpenes
SQT : SOA from sesquiterpenes
POLB : oligomerized SOA from biogenic species (ISP, TRP)
POLA : oligomerized SOA from anthropogenic species (AROM)

Conclusions

- The sensitivity of ozone formation in Switzerland has changed towards more NO_x-limited regime since 1993.
- Isoprene is more effective for ozone in southern Switzerland.
- Model results suggest that there is enough ammonia in the domain and inorganic aerosol formation is mainly limited by HNO_3 (NO_x emissions).
- SOA is produced dominantly from biogenic precursors such as monoterpenes and sesquiterpenes as well as oligomerization of particles. SOA formed from isoprene oxidation is negligible in Switzerland.
- Currently modelled SOA concentrations are lower than those derived from measurements. Using volatility approach might improve it.

Acknowledgements

FOEN

Environ

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